We have reviewed ORP/OSR-2002-21, Rev. 0, *DNFSB Seismic Concerns for Low Activity Waste/High Level Waste Basemat Construction*, dated July 1, 2002, and are in agreement with the positions and recommendations put forth herein.

____________________________________ __________________

Q. A. Hossain Date
Sections 3A and 3B

____________________________________ __________________

B. Gutierrez Date
Sections 3A and 3B

____________________________________ __________________

L. F. Miller Date

ORP/OSR-2002-21
Revision 0

DNFSB SEISMIC CONCERNS FOR LOW ACTIVITY WASTE/HIGH LEVEL WASTE BASEMAT CONSTRUCTION

Definition, Status, and Recommendations (6-29-02)

July 1, 2002

U.S. Department of Energy
Office of Safety Regulation
P.O. Box 450, H6-60
Richland, Washington

Approved by: ____________________________________
Safety Regulation Official

Date: ____

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DNFSB SEISMIC CONCERNS FOR LOW ACTIVITY WASTE (LAW)/HIGH LEVEL WASTE (HLW) BASEMAT CONSTRUCTION
Definition, Status, and Recommendations (6-29-02)

1.0 BACKGROUND

The River Protection Project Waste Treatment Plant (WTP) selected DOE-STD-1020-94 as the seismic standard for the facility in 1997, using the contractually required standards-based integrated safety management selection process.

In order to perform the facility design, the previous contractor, BNFL Inc., selected the most limiting site-specific peak ground acceleration (.26 g horizontal, .18 g vertical) associated with the 2,000-year recurrence interval, along with the corresponding site-specific seismic response spectra. (A 2,000 year recurrence interval was selected because the facility is Performance Category 3 using DOE-STD-1020, having significant radiological hazard (Hazard Category 2), but less than a nuclear reactor). The U.S. Department of Energy (DOE), Office of Safety Regulation (OSR) approved this selection in 1997. Subsequently, the current contractor, Bechtel National, Inc. (BNI), adopted the same criteria in 2001, after a due diligence review.

These acceleration values, and associated spectra, come from the seismic hazard report for the Hanford Site (currently called the Geomatrix report, named after the prime contractor). This report refined the seismic hazard model for the region that was begun in 1981 for the Washington Public Power Supply System's reactor sites, and that was subsequently updated to accommodate the latest seismic considerations in 1989 and 1993-1996. The acceleration and spectra were accepted for the DOE Hanford Site in 1997 by the DOE Richland Operations Office (RL). The determination was extensively peer reviewed, revalidated by the previous privatized contractor, BNFL Inc., and independently reviewed by OSR contractors from the U. S. Corps of Engineers and Lawrence Livermore National Laboratories (LLNL) in 1999. It is also consistent with the latest recommendations of the USGS (National Earthquake Hazard Reduction Project, or NEHRP).

In the first half of 2002, BNI's seismic design was finalized in parallel with the final design of the basemat. As this information became available during this period, the OSR conducted an extensive review. Seismic modeling of the structure, compliance with the provisions of the applicable codes of construction, ACI 349 and ACI 318, and demand/capacity ratios at critical locations throughout the LAW and HLW structures were reviewed. The purpose of this review was to ensure the preliminary design incorporated the design criteria required by 10 CFR 830.206. In addition, the review ensured that the final design of the basemat and connecting wall dowels provided adequate safety, complied with all legal requirements, and was consistent with the contractual top-level safety standards and principles. Having ensured this, on June 27, 2002, after the completion of this review, the OSR approved the Safety Evaluation Report for basemat construction. On June 28, 2002, an Authorization Agreement for HLW and LAW building basemat construction was awaiting signature by BNI and DOE.

2.0 CHRONOLOGY OF DEFENSE NUCLEAR FACILITY SAFETY BOARD (DNFSB) CONCERNS:

The DNFSB staff (the Staff) raised its first questions concerning the seismic assumptions used in the design, in informal discussion on March 21-22, 2002. Initially, the focus of these was the adequacy of the geotechnical survey of the site performed by Shannon-Wilson (all of these issues have subsequently been resolved by providing additional information). Follow-up discussions were held on April 18, 2002. On May 22-23, 2002, the staff revisited these issues, in combination with a site visit by Vice Chairman Eggenberger. (This meeting first asked for a specifically formatted load path presentation, discussed below). The seismic concerns of the Staff that were unresolved were discussed at a June 5, 2002, meeting held in San Francisco. The ductile detailing concern was described at this meeting in some detail. Since that meeting, frequent discussions have occurred in an attempt to resolve the remaining open issues, described below.

3.0 CURRENT SEISMIC CONCERNS

A. Load Path Representation: A graphical representation of the three-dimensional load path distribution for the design basis seismic load cases for the LAW and HLW structures was requested by the Vice Chairman (May 22, 2002). A format that was used on a K reactor presentation was requested. The Staff plans to use this information to assess the adequacy of the design.

Discussion: In this concern, the Staff has not raised a question concerning the acceptability of the seismic analyses of the LAW and the HLW buildings and evaluation of the basemats, but rather the ready accessibility for their review of the calculation packages. BNI is confident that its seismic analyses and evaluations are sound (see Appendix A for elaboration on this assertion). OSR also considers that the analyses and design for the basemat and, basemat to basement wall connections are sound. The design adequacy of these was extensively reviewed by Q. Hossain of LLNL and other OSR reviewers. The review included an evaluation of the conservatism in the floor-by-floor representations of the seismic acceleration values obtained from the soil-structure interaction analysis. The demand-over-capacity ratios for the basemat and, basemat to basement wall connections at the most critical locations were observed to have at least 15% margin over the minimum requirements. A Safety Evaluation Report (SER) documenting this conclusion was issued Thursday, June 27, 2002. Most of the information presented relates to the adequacy of the structure, generally, a topic still under active review by the OSR as part of the Preliminary Safety Analysis Report (PSAR) review. In addition, as discussed in the next concern below, the basemat and basemat to wall connection have substantial margin. The uncertainties in the building seismic analysis assumptions or uncertainties in the seismic input motion definitions, which are inherent in the present state-of-the-art methods, are unlikely to result any changes in the reinforcement of the basemat, or the basemat to wall connections.

In its response to the concern, BNI provided isometrics with associated loads in all walls, throughout the structure. The Staff did not find these adequate, and requested a detailed wall-by-wall narrative interpretation of the results, similar to the referenced K reactor report, which is about 1 inch thick. BNI estimates preparation of this format will take 6-8 weeks for two-three key engineers to pull together. BNI has contacted the SRS person who produced the report, and may be able to reduce this estimate somewhat, with his assistance. BNI is confident that when this report and associated presentation is pulled together, its results will not impact the acceptability of the seismic analysis and design of the basemat.

Load Path Representation Recommendation: BNI should provide the information requested by August 30, 2002.

B. Ductile Detailing of Wall-Slab Panel Zones: On May 22, 2002, briefly, and more extensively on June 5 and 19, 2002, the Staff expressed concern that the connection of the basemat to the west wall of the HLW building may not have adequate ductility against seismic loading, and that the design of the connection should "mimic" a ductile beam-column connection.

Discussion: The HLW west wall runs the width of the building and is subject to the following loading at the wall to wall/slab intersection:

- Total Moment Demand: - M = -183 ft-k/ft (tension outside) (Col. Line K to S)
  +M = + 11 ft-k/ft (tension inside) (Col. Line B to D)
- Moment Capacity: M = +- 276 ft-k/ft
- Seismic Demand: M = -55 ft-k/ft (Col. Line K to S)
- Section has a seismic reserve equivalent to 1.7 times the present seismic load of 55 ft-k/ft (276-183)/55 = 1.7)

The current rebar detailing for seismic considerations meets the latest national consensus seismic detailing provisions. These are from ACI 318 Supplement and were approved by the OSR as part of the contractually required, standards-based integrated safety management process. The Staff interpreted the ACI code provisions that ensure ductility of beam to column joints to be not only desirable, but also mandatory, for this wall to slab joint. The OSR reviewers found the details proposed by the Staff to have the potential for providing additional ductility, but could not ascertain this confidently because such details have not been extensively used or reviewed by the ACI code committees. The Staff proposed an alternate rebar configuration that would be acceptable to them. BNI pointed out structural inadequacies in this design concept and after extensive BNI-Staff discussions a concept was arrived at that could be constructed and would satisfy the Staff's concern regarding joint ductility.

The OSR considers joint ductility an important consideration in seismic design, however, in this case, the seismic loads of the critical wall panel joints are a small fraction of the total load. Also, since there is a substantial design margin of 1.7, the connection has the ability to withstand a seismic load significantly larger than the design basis load without undergoing brittle failure. If the ACI code would have intended to require the application of beam-column connection provisions for wall-basemat connections, it would have stated so, because wall-basemat connections are very common. Given BNI's implementation of national consensus code provisions in the design, and the ample seismic margin in the design, the OSR considers the HLW west wall seismic detailing provides adequate safety. This position was developed after review by Q. Hossain of LLNL and consultation with B. Gutierrez of SRS. Their opinion is that ACI code presently does not require the application of beam-column connection provisions to wall-basemat connections and the need for improving the present code provisions for added ductility has not been discussed enough in the industry for developing a definitive code provision.

Also, from a safety management perspective, the OSR has no safety basis for backfitting an ad hoc detailing standard that exceeds the latest code requirements.

<u>Ductile Detailing Recommendation</u>: Do not implement the additional confinement rebar detail of the HLW long unsupported basemat to basemat wall joint.

(Evaluate any similar structural cases in the WTP, prior to construction. Consider implementation of additional confinement if any cases exist where ample seismic capacity, comparable to that for the HLW basemat wall case, does not exist.)

C. <u>Adequacy of Design Basis Seismic Ground Motion Peak Ground Acceleration and Associated Spectra.</u>

1a. Postulated Increased Probability of Activity of Local Anticlines: All of the anticlines were formed as part of the same stress field and all are faulted on the north flank (reverse). There is evidence that one or more are "capable." Why should not all of the anticlines and the associated faults be considered "capable" in a Probabilistic Analysis?

<u>Discussion:</u>

- Geologic and Seismological Data Interpretation
  - An expert team of geologists, geophysicist, and seismologists, with Pacific Northwest and Hanford site-specific knowledge, collectively assembled the geologic and seismologic data used for determining the probability of activity.
  - An expert team of probabilistic hazard practicians[AMT1]worked worked d worked with the technical team to determine the relative probability of activity and the final recurrence rates to ensure that they were appropriately selected following the procedure established by the community. The team stands by those results.

- The Geomatrix report was subjected to a formal and informal peer review by members of the geotechnical community.

- The US Geological Survey's (USGS) seismic hazard assessment's 2500-year ground motion compares favorably with this study (see figure 3 at end of section).

- The USGS has used the Geomatrix report, and are incorporating many of the faults and slip rates in their current update of the US hazards maps. The local experts were involved in that process and contributed site information to those maps.

- **Methodology for Assessing Probability of Activity**

  - The methodology in Table 3 (below) follows accepted practice defined by the seismic hazards assessment community.

  - Table 3 is an attempt to quantify the relative activity among the structures/faults, based largely on the evidence for recent movement. We have added the rankings to the probability of activity table (Table 3) previously transmitted (as Table 4). These rankings are not exactly what was used originally, but do reflect our current thought and best recollection. The total possible number of points or score for any structure is 1.0. The first column is the **source**. The next four columns deal with evidence for **Quaternary and Recent deformation or activity**. These columns are considered equally important. They are ranked equal and are given values of 0.2 each. The last two columns are considered less important because they are the **Pre-Quaternary History,** which is based on long-term growth rates, and **orientation** with respect to the current stress field. They are ranked equal and given a possible value of 0.1 each. The total score for each structure is reported in column 1 (Structure) below the value given in Table 3.1of the Geomatrix report. The scores for all source structures are similar and a uniform value of **0.25** was applied except for the Hog Ranch anticline (0.1), the Saddle Mountains (0.5) and Toppenish Ridge (1.0).

  - Using the methodology of Table 3, it is not reasonable to get a probability of activity given in the "Parametric Run Assessment of Impact of Assumptions Regarding Probability of Activity" table (in the DNFSB request for information) on any but the Toppenish Ridge structure. This is because there is little to no evidence for Quaternary deformation or activity on the remaining structures.

  - The structure/fault properties used to assess the probability of activity (Table 3) are the same used by the U.S. Nuclear Regulatory Commission (NRC).

- The weight given to the properties columns in Table 3 is consistent with the NRC's definition of a capable fault.

- Probability of Activity values is consistent with new models for the development of the Yakima Fold belt. Since the original work done for developing the Hanford seismic hazard model, new models have been presented in the literature. These new models (Mege 2001, and Mege and Ernst 2001, and papers cited therein) have related the Columbia River basalt and the Yakima Fold belt to hot spot/mantle plume dynamics. The Probability of Activity values are consistent with these newer tectonic models.

- **Safety Management Considerations**: The discussion above explaining why the parameters chosen are appropriate was written by the authors of the Geomatrix study that defines the peak ground acceleration for the Hanford site. The study was completed in 1996, accepted by DOE in 1997. The study was reviewed internally, by peers, and was accepted by the DNFSB (reportedly including the current Staff consultant, P. Rizzo). The study was then revalidated by BNFL in 1998 as part of the standards based integrated safety management standards setting process. The OSR approved the BNFL standard proposal in 1999 (after the review by independent, recognized experts from the U.S. Army Corps of Engineers, M. E. Hynes, and R. Murray of LLNL). No new seismic information has been introduced in the interim that affects the conclusions. All of the seismic data and review information currently questioned by the Staff has been available to the DNFSB for a timely review, but the DNFSB review has not been timely in this case.

<u>Postulated Increased Probability of Activity of Local Anticlines Recommendation</u>: The OSR should not change the approved Hanford and WTP design basis peak ground acceleration and associated spectra given the strong preponderance of expert opinion that these criteria are appropriate for this location.

1b. Following the June 5, 2002, meeting, the Staff requested a calculation of the effect on the peak ground acceleration if the local anticlines were assumed to have greater activities than assumed in the current Hanford (and WTP) seismic design basis. (The requested parameters are shown in Appendix B.)

<u>Discussion</u>: The Staff stated that the requested parameters were based on a review and reasonable interpretation of the Slip Rates reported in Table 3-4 of the Geomatrix Report. As discussed above in Item 1a however, the activities used in the Geomatrix report were arrived at by a thorough and comprehensive expert elicitation process, and are considered most appropriate for DOE to adopt in this calculation.

Preliminary response to the above comment is presented in the attached tables and figures for only three frequency points. The complete response including the revised tables and figures requested will be provided on July 8, 2002.

As requested, parametric studies were performed for probability of activities, for three sets of probabilities. The first set, as listed in Table 3-1 of Geomatrix (1996), referred to in this response as the "Original" set of probabilities of activity. The DNFSB proposed probabilities are referred to here as "Modified #1", which all suggest equal or greater effective activity of the seismic sources. During earlier discussions with the Staff, an intermediate set of probabilities was discussed, referred to here as the "Modified #2" set.

Table 1 indicates these three sets of probabilities of activity for the Yakima Fold seismic sources.

Figure 1 indicates the change in the composite Yakima Fold's hazard curve by comparing the original hazard curve with those using the two sets of modified probabilities of activity. The readily available hazard curves for three spectral ordinates – PGA, 0.3 sec, and 2.0 sec – are indicated.

Figure 2 is similar to Figure 1 except the total hazard curves are presented.

Table 2 uses the hazard curves presented in Figure 2 to derive the 2,000-year spectral ordinate values considering the three sets of probabilities of activity for the Yakima Fold seismic sources. Percentage changes of the spectral ordinate values are indicated in this table, considering each of the two sets of modified probabilities of activity, relative to use of the original probabilities.

Anticline Activity Reparameterization Recommendation: None. The recalculation requested has been started. The calculations performed do not indicate any unusual sensitivity of the calculated ground acceleration to assumptions regarding the probability of activity of anticlines. The complete data set requested will be provided by July 8, 2002. The probability of activity of anticlines that is appropriate to use is the set chosen in the Hanford (and WTP) seismic design basis, as discussed in Item 1a above.

2. The Ground Motion Attenuation Model may not be adequately conservative.

Discussion: The analysis assumes that the Hanford site has the same response as the California sites to model the attenuation of larger basement rock earthquakes as they pass through overlying structures and sediments. The Staff's concern is that at certain periods (1 and 5 Hz peaks, 2 Hz trough), the spectral amplification ratios used in the analysis do not support the conclusion that the site response for the 200 East area is the same as the generic California site data used in the analysis, contrary to the analysis assumptions. (There is no local earthquake record (for larger earthquakes) to provide direct information on the attenuations that would occur in a design basis earthquake.) The Staff suggested three alternative extensions of the analysis that would allay their concern:

(1) Increase design response spectra 20 %: The basemat and basemat to wall connections have adequate margin to make this increase without impact on the physical design. However, BNI opposes this arbitrary change, due to the reanalysis required, and their judgement that some equipment in the rest of the facility would not have such margin. OSR's judgement is that adequate margin likely exists to accommodate such an increase. However, this is only an intuitive judgement, and is less informed on the details of BNI's design, which is still being developed for equipment and structure.

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(2) Redo analysis with larger group of time histories and take into account a broader range of soil properties (using actual Hanford measured data), then look at mean amplification comparing Hanford to CA. BNI has asked Geomatrix to reperform this reanalysis and expects to complete it July 1, 2002.

- Even though the Staff suggested it as an alternative, the Staff has stated that it is skeptical of this alternatives capacity to resolve the concern. ("Alternate may not resolve question entirely, but may help to define the magnitude of the difference in amplification"). The Staff suggested doing Alternate 1 in parallel. BNI and OSR experts expect the extensive averaging across many more paths will reduce the difference in amplification in certain frequency ranges, but not eliminate them.

(3) Perform a "true" site amplification study and use an approach similar to that adopted for the SRS; i.e. source parameters and random vibration theory over various paths. Extensive reanalysis would be required, with little reduction in uncertainty, given the lack of strong earthquake data in the region.

Attenuation Model Recommendation: Provide the requested data for alternative two above, but do not change the design spectra at this time.

3. Characteristics of the Input Motions Used in Site Response Calculations:

Discussion: The Staff is concerned about the reason for certain high frequency peaks that appear in the in-structure response spectra. The specific nature of his concern has not been provided. In follow-up discussions, the Staff requested the Husid energy plot of the seismic DBE time histories, as well as the rock outcrop motions at 3 km from the Geomatrix 1996 report. The records were provided by BNI.

Input Motion Characteristics Recommendation: None, pending additional questions.

Appendix A. Process for Load Path Evaluation and Analysis Quality Assurance

Throughout the initial design phase, the goal was to limit the average in-plane shear in the shearwalls to $4\sqrt{f_c'}$, based on using half of the ACI code allowable of $8\sqrt{f_c'}$. With added shear due to torsion, openings in shearwalls, etc, $4\sqrt{f_c'}$ could not be maintained in all walls, but the average was generally achieved. Fixed-base modal analyses were performed in the initial design phase to determine dynamic response. Dominant modes were approximately 8 Hz in East-West direction and 10 Hz in North-South direction. Both values are significantly higher that the 5 Hz frequency corresponding to the peak of the project response spectra (free-field), indicating that the facility had sufficient stiffness to limit global seismic loads to reasonable values. Although this frequency comparison did not include the beneficial effects of soil-structure interaction (SSI), it gave an indication of seismic behavior.

With the project in detailed design phase, extensive analyses have been performed to provide a thorough understanding of load paths and to validate that the load paths are reasonable. To get an overall view of lateral load flow, the shear in each wall was broken into the percentage of total shear, and the percentage evaluated at each level. The results showed that there is a uniform distribution of shearwall loads, with higher loads being developed in some areas due to torsion (near the Annex Building) and discontinuities in the diaphragms, as expected. In addition to the shear flow paths based on percentages, stress contour plots and displaced shape plots from the finite-element model (FEM) were evaluated in walls and floors for the dominant load cases. Evaluating the stress plots provided validation of the lateral load flow and gave the complete picture of all stress components used in rebar design. The displaced shape plots showed that there was no unreasonable torsion or unusually high local displacements.

Regarding analysis quality, multiple checking and review cycles have occurred leading to assurance that the analysis methodologies, loading, accuracy, and completeness is assured. All natural phenomena hazard loads, dead loads, and live loads have been developed per project criteria and checked. Particularly on the seismic load development from SSI analyses, both internal checking and peer reviews were performed, and the analyses were scrutinized by the Office of Safety Regulation (OSR). Extensive analyses were performed to develop thermal loads using computational fluid dynamic methodologies. All thermal analyses were subjected to internal checking, and OSR reviews. All structural calculations, including the FEM, have undergone internal checking and reviews, sent to the Chief Engineer for review, and reviewed extensively by OSR.

Appendix B. Recalculation of Seismic Probabilistic Analysis Using Parameter Assumptions

As regards Table 3-1 in WHC-SD-W236A-TI-002, Re. 1A, October 1996 (the Geomatrix Report), the Staff requested that the seismic probabilistic analysis be recalculated using the Probability of Activity Values listed below. All of the values for the Probability of Coupling listed on Table 3-1 should remain unchanged, as should all other parameters contributing to the Analysis.

Assumptions Regarding Probability of Activity

Fold	Probability of Activity
Umtanum-Gable Mountain	0.75
Rattlesnake-Wallula	0.50
Manastash Ridge	0.50
Saddle Mountains	0.75
Horse Heaven Hills, NW	0.50
Horse Heaven Hills, NE	0.50
Rattlesnake Hills	0.75
Yakima Ridge	0.50
Frenchmen Hills	0.50
Toppenish Ridge	1.0
Hog Ranch	0.5

The Staff requested that the results be shown as comparisons to the existing results on at least the following Tables and Figures. The Staff suggested that other tables and figures be added to the comparison if such figures and tables help to provide a better understanding of the results.

Table 5-1 (East Area) for at least Return Periods of 1000 years, 2000 years and 10,000 years.
Table 5-2 (East Area) for at least Return Periods of 1000 years, 2000 years and 10,000 years.
Figure 5-1b
Figure 5-2b
Figure 5-3b
Figure 5-4b
Figure 5-11b
Figure 5-15b (PGA only)
Figure 5-16 East Area Only are on four separate 8 ½ X 11” individual Figures
Figure 5-19

Appendix C. References

BNFL Inc. (1999) Validation of the Geomatrix Hanford Seismic Hazard Report for Use on the TWRS-P Project, prepared for Tank Waste Remediation System Privatization Project, Rev. 0 (draft) dated February 18, 1999.

Ernst, R.E., and Buchan, K.L., editors, 2001, Mantle plumes: their identification through time, Geological Society of America Special Paper 352, pp. 1-577.

Geomatrix Consultants (1996b). Probabilistic Seismic Hazard Analysis, DOE Hanford Site Washington, WHC-SD-W236-TI-002, Revision 1a, prepared for Westinghouse Hanford Company, Richland, Washington, October 1996.

Mege, D, 2001, Uniformitarian plume tectonics: The post-Archean Earth and Mars, in Ernst, R.E., and Buchan, K.L., Mantle plumes: their identification through time, Geological Society of America Special Paper 352, pp. 141-164.

Mege, D., and Ernst, R.E., Contractional effects of mantle plumes on Earth, Mars and Venus, in Ernst, R.E., and Buchan, K.L., Mantle plumes: their identification through time, Geological Society of America Special Paper 352, pp. 103-140.

Table 1. Assignment of Probability of Activity for the Yakima Folds Seismic Sources

Assignment of Probability of Activity for the Yakima Folds Seismic Sources

Fold	Probability of Activity Original	Modified Set #1	Modified Set #2
Umtanum-Gable Mtn.	0.25	0.75	0.50
Saddle Mtns.	0.50	0.75	0.50
RAW	0.25	0.50	0.50
Frenchman Hills	0.25	0.50	0.50
Rattlesnake Hills	0.25	0.75	0.50
Yakima Ridge	0.25	0.50	0.50
Toppenish Ridge	1.00	1.00	1.00
Manastash Ridge	0.25	0.50	0.50
Hog Ranch	0.10	0.50	0.10
Horse Heaven Hills	0.25	0.50	0.50

Table 2. Changes to Uniform Hazard Spectra from Modification of the Probabilities of Activity

Changes to Uniform Hazard Spectra from Modification of the Probabilities of Activity

Freq. (Hz)	Period (s)	Hazard Level	Original PGA/Sa (g)	Modified Set #1 PGA/Sa (g) [% Change]	Modified Set #2 PGA/Sa (g) [% Change]
33.00	0.03	5.0E-04	0.236[2]	0.310 [31]	0.278 [18]
3.33	0.30	5.0E-04	0.500[2]	0.662 [32]	0.591 [18]
0.50	2.00	5.0E-04	0.127[2]	0.142 [11]	0.135 [6]

Variation from values given in Table 5-1 of Geomatrix (1996) due to arithmetic rounding and differences in the way Geomatrix and Bechtel performed interpolation – see Section 6 of BNFL Inc. (1999)

Table 3. Assessment of Probability of Activity

Assessment of Probability of Activity						
Structure (Activity, Table 3-1)	Association with Historic Seismicity	Evidence for late Quaternary fault displacement	Geomorphic evidence for geologically recent deformation	Association with neighboring structures showing evidence for Quaternary deformation	Pre-Quaternary history of deformation	Orientation relative to present stress field
Value (total = 1.0)	0.2	0.2	0.2	0.2	0.1	0.1
Toppenish Ridge **(Table 3.1 - 1.0)** **Score = 1.00**	**Yes**, Native American legends **0.2**	**Yes,** Campbell NEHRP study **0.2**	**YES. MANY MAPPED fault scarps.** **0.2**	**Yes**. Simco Volcanic field and bulge in Horse Heaven Hills **0.2**	**Yes**, based on long-term growth rates. **0.1**	Yes **0.1**
Hog Ranch-Naneum Ridge Anticline **(Table 3.1 - 0.10)** **Score = 0.10**	No **0**	No **0**	No **0**	No **0**	**Yes**, based on long-term growth rates **0.1**	No **0**
Frenchman Hills **Table 3.1 – 0.25)** **Score = 0.20**	No **0**	No (Pliocene to early Pleistocene) (Geomatrix 1990) **0**	No **0**	No **0**	**Yes**, based on long-term growth rates **0.1**	**Yes** **0.1**
Saddle Mountains **(Table 3.1 = 0.50)** **Score = 0.40**	No (Saddle Mts EQ swarm north of structure) **0**	**Yes**, Normal fault in graben. (not as extensive as reported. **0.2**	No. Evidence proposed is not tectonic. **0**	No **0**	**Yes**, based on long-term growth rates **0.1**	**Yes** **0.1**
Manastash Ridge, (continuation of SM) **(Table 3.1 - 0.25)** **Score = 0.20**	No **0**	No **0**	No **0**	No **0**	**Yes**, based on long-term growth rates **0.1**	**Yes** **0.1**
Umtanum Ridge-Gable Mt. **(Table 3.1 - 0.25)** **Score = 0.25**	No **0**	**Yes** – Central fault – small tear fault (tectonic ?) **0.05**	No **0**	No **0**	**Yes**, based on long-term growth rates **0.1**	**Yes** **0.1**
Yakima Ridge **(Table 3.1 - 0.25)** **Score = 0.25**	No **0**	No **0**	No **0**	No **0**	**Yes**, based on long-term growth rates **0.1**	**Yes** **0.1**
Rattlesnake Mt **(Table 3.1 - 0.25)** **Score = 0.20**	No **0**	No **0**	No **0**	No **0**	**Yes**, based on long-term growth rates **0.1**	**Yes** **0.1**
Rattles-Wallula **(Table 3.1 - 0.25)** **Score = 0.25**	No **0**	**Possibly** (Finley Quarry >200Ka **0.05**	No **0**	No **0**	**Yes**, based on long-term growth rates **0.1**	**Yes** **0.1**
Horse Heaven Hills-NW **(Table 3.1 -0.25)** **Score = 0.20**	No **0**	No **0**	No **0**	No **0**	**Yes**, based on long-term growth rates **0.1**	**Yes** **0.1**
Horse Heaven Hills NE **(Table 3.1 - 0.25)** **Score = 0.20**	No **0**	No **0**	No **0**	No **0**	**Yes**, based on long-term growth rates **0.1**	**Yes** **0.1**

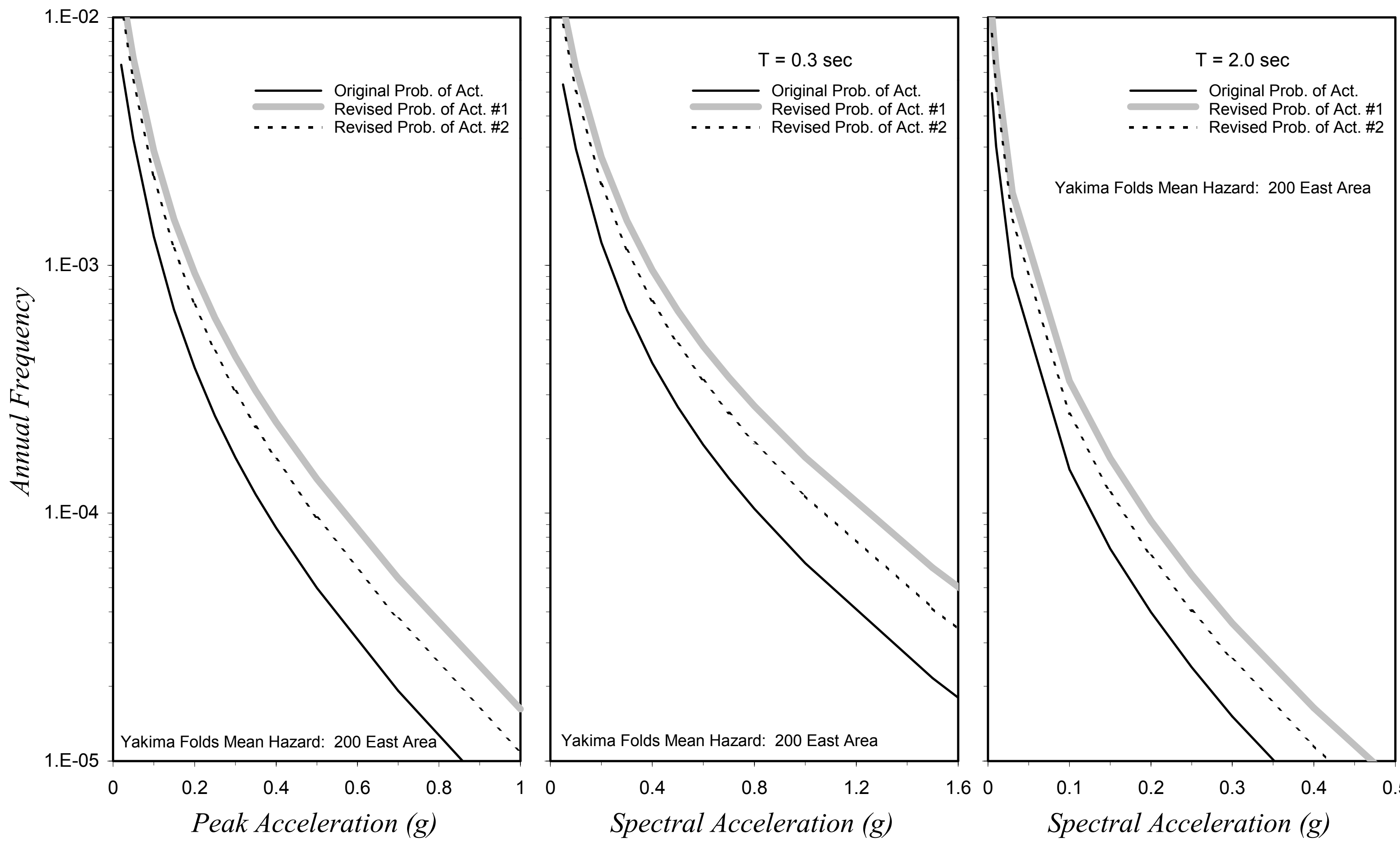

Figure 1. Comparison of mean hazard curves from the Yakima Folds at the 200 East Area for original and modified sets of probabilities of activity.

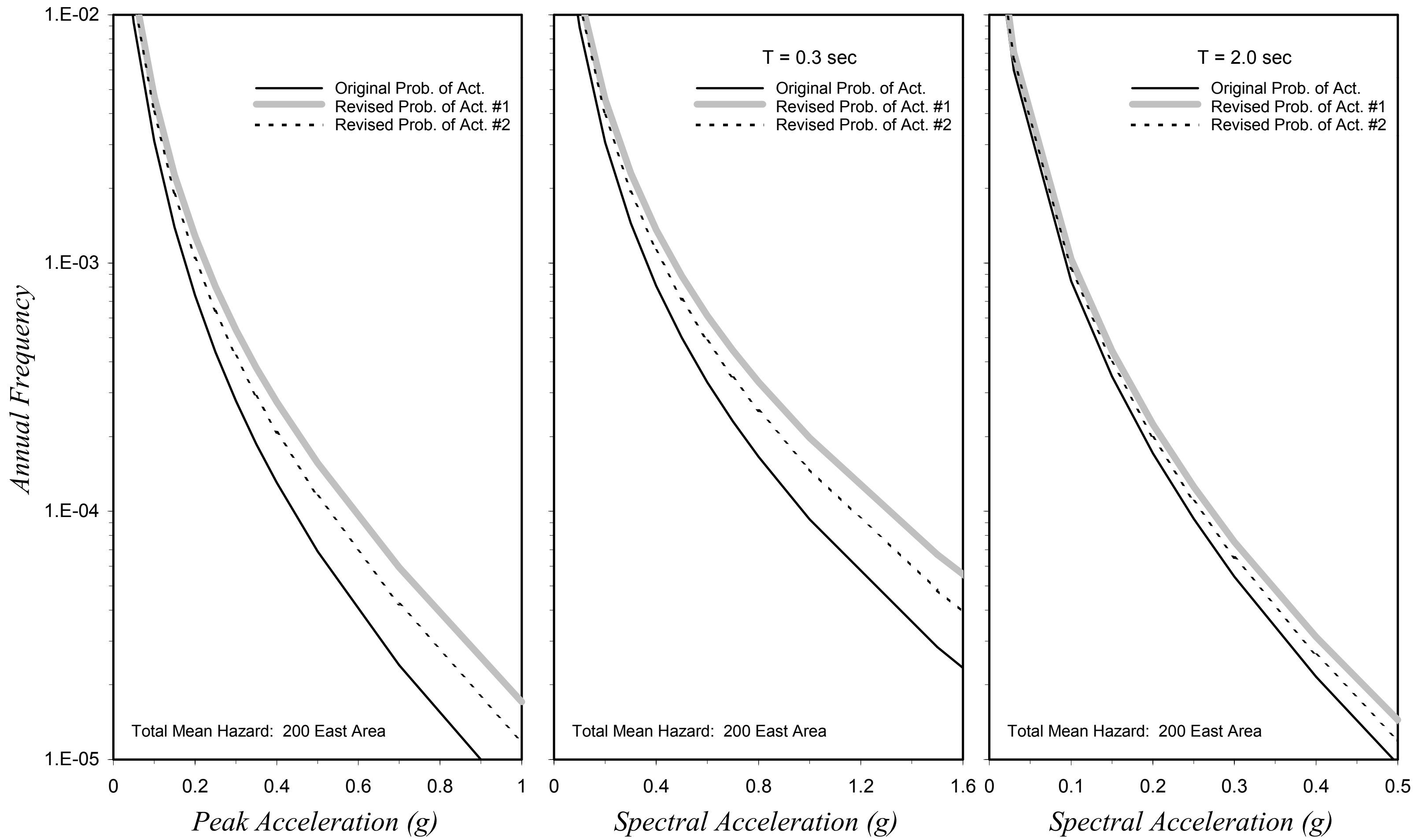

Figure 2 Comparison of total mean hazard curves at the 200 East Area for original and modified sets of probabilities of activity.

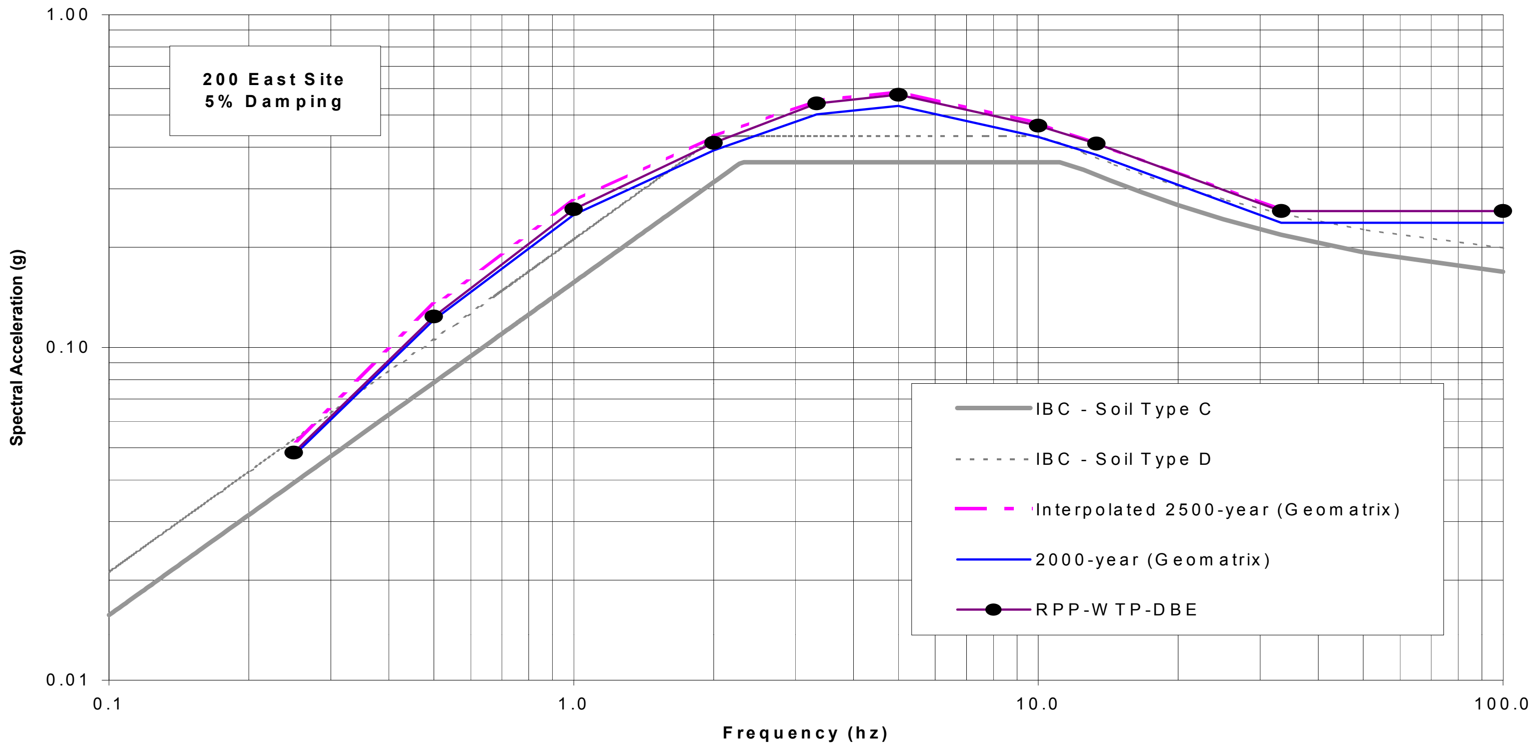

Figure 3. Comparison of Geomatrix 2000- and 2500-year motions for 200-East Area with DBE and IBC/USGS

[AMT1]This is probably correct but I have never used it this way. (practitioners?)